

## SELF-POWERED WIRELESS SWITCH

### TECHNICAL FIELD

The present invention generally relates to wireless switches, and more particularly to a wireless switch such as for use in an automobile or aircraft environment which does require a separate source of electrical power and associated wiring.

### BACKGROUND ART

During the last decade, the automotive industry has experienced very significant growth in the electrical/electronic content of automobiles. The future growth rate of this content is predicted to become exponential. One cause for this significant growth is the availability of new vehicle systems such as cabin communication systems (CCS), active noise control systems, automobile personal computers, and on-board navigational systems. When any of these systems is added to a vehicle, interconnection is made using extensions of the vehicle's conventional wiring/electrical distribution system technology. This conventional technology is characterized by very complex arrays of wire harnesses, interconnecting switches, motors, relays, electronic modules and the like. The proliferation in the quantity of the components required to implement new features is becoming difficult to manage from cost, serviceability and packaging viewpoints.

For the past thirty years, multiplexing has been extolled as a technology capable of addressing these issues. However, to date, no major automotive program has received large benefits from this technology. Significant reasons include the continued need for complex wire harness arrays to interconnect switches and sensors with multiplexed electronic modules and multiple power distribution feeds.

As shown in Figure 1, conventional automotive control and electrical power distribution systems share a common architecture. Low power input signals

from remotely located switches 10 are transmitted through wires 12 to a controller 14. Controller 14 typically includes a control algorithm for selectively distributing power to activate remotely located external loads 16 via additional wires 18. The necessity of supplying power from a vehicle battery 20 to each of the switches, 5 controller, and loads generally results in a very complex electrical distribution system. As the number of systems on a vehicle increase, the complexity of the distribution as well as the bulk of associated wiring harnesses increases.

As a result, wireless communication between switches and controllers has been proposed as a way of reducing the number of wires. However, the need to 10 supply electrical power still requires the use of a wiring harness, thereby negating much of the advantage gained by using a wireless communication system. In other words, a maximum reduction in the number of wires to zero will not be achieved, while full freedom to locate a switch anywhere in the vehicle will not be attained.

The use of a dedicated battery to provide power locally at individual 15 switches can eliminate the need for power supply wires, but conventional batteries have a limited life. Thus, continual battery replacement becomes a major drawback, particularly in vehicle applications where a large number of switches are used. Thus, for applications such as automobiles and aircraft, a power source with at least a twenty-year life expectancy is required. As a consequence, a need exists for a 20 wireless switch arrangement that does not require any external power distribution wiring while also being capable of attaining the desired twenty-year life expectancy.

#### **DISCLOSURE OF INVENTION**

It is therefore an object of the present invention to provide a wireless 25 switch arrangement that generates its own electrical power to remove any need for a direct connection to a battery or other external source of electrical power.

It is another object of the present invention to provide a wireless switch having a local energy harvesting arrangement dedicated to the switch circuit to remove any need for an external power supply wire connection to the switch.



It is yet object of the present invention to provide a wireless switch having at least a twenty-year power source.

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~~In accordance with these and other objects, the present invention provides a twenty-year life, self-powered wireless switch for automobiles, aircraft (e.g., jet engines), elevators, and other applications requiring transmission of control signals/information from an inaccessible or rotating location. The self-powered wireless switch is provided with a wireless transmitter, and an energy harvesting device arranged to produce electrical power for operation of the wireless transmitter when actuated by a switch. In accordance with aspect of the present invention, the energy harvesting device includes a piezoelectric element arranged to be distressed upon actuation of the switch. In accordance with another aspect, the energy harvesting device can include a tritium lamp arranged to energize a phosphor coating to produce light upon actuation of the switch, and at least one photo detector arranged to receive the light and generate the electrical power. In accordance with still another aspect of the present invention, the energy harvesting device includes at least one photo detector arranged to receive the light from a lamp. Preferably, the lamp can be arranged to generate black light.~~

Thus, the present invention provides a switch arrangement that can be located without regard to insuring accessibility of a wiring harness or connector. This freedom to locate a switch anywhere without being confined by a wire harness reduces the complexity of the power distribution system in such applications as automobiles, aircraft and HVAC equipment.

The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

## BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a block circuit diagram of a conventional wired electrical power distribution system for a switch and controller arrangement;

5 FIGURE 2 is a block circuit diagram of a self-powered wireless switch in accordance with the present invention;

FIGURE 3 is a block circuit diagram of a first embodiment of a self-powered wireless switch using a piezoelectric switch arrangement;

10 FIGURE 4 is a block circuit diagram of a second embodiment of a self-powered wireless switch using a tritium lamp arrangement; and

FIGURE 5 is a block circuit diagram of an alternative arrangement for the second embodiment which uses a source of black light.

## BEST MODE FOR CARRYING OUT THE INVENTION

Figure 2 illustrates a wireless switch arrangement 100 in accordance with the present invention. As described in more detail below, a wireless switch 102 is arranged to be self-powering, thereby limiting the use of a wiring harness to connecting a controlled load(s) 104 to a source of electrical power such as a battery 106. In other words, the present invention is able to eliminate the connection of any wiring to a user operated control switch. Thus, in accordance with the present invention, the wireless switch is arranged to perform (1) actuation; (2) communication; (3) backlighting (i.e., switch illumination); and (4) energy harvesting. The term "self-powered" or "energy harvesting" is used in this description to define a switch assembly that does not need servicing for twenty years and does not require a direct wire connection to a vehicle's normal power distribution system.

25 Referring now to Figure 3, a self-powered wireless switch arrangement 200 is shown in accordance with a first embodiment of the present invention. More specifically, a piezoelectric switch element 202 is arranged to be actuated by a user via a switch handle or button 204. The switch handle operates to apply a mechanical force to deflect or distress the piezoelectric element, which in

turn includes a piezoelectric material (PZT- lead zirconate titanate) that operates to convert the mechanical force into an output electric voltage and current. The generated electric power can be directly connected to a wireless transmitter circuit 206, or stored by a capacitor 208. The capacitor would then become the power source for operation of wireless transmitter circuit 206.

The wireless transmitter circuit can be implemented using RF, infrared, ultrasonic and other wireless technologies known to one of ordinary skill in the art. For example, a 13.6 MHz transmitter circuit can be provided that only requires approximately 1 milliwatt to power the transmitter. However, the output of the transmitter is not encrypted. Another possible transmitter is a TIRIS ("Texas Instrument Registration and Identification System") transponder, manufactured by Texas Instruments (TI). This device includes an interrogator that is powered by the energy generated or harvested , and is arranged to generate radiation that is stored for a period of 50 ms. Subsequently, the transponder radiates information at 134 KHz for 50 ms while the TIRIS interrogator stops transmitting radiation and goes into a 50 ms read mode. The TIRIS device can transmit 64 bits of information during each 50 ms burst. This information content allows for use of sufficient coding to distinguish one switch location from another. In addition, because the TIRIS device uses a higher frequency output, less energy is needed to actually send the signal. Thus, the TIRIS device consumes less power than a lower frequency transmitter. Furthermore, the TIRIS transponder is rugged and small, and therefore practical for use in hostile environments such as typically encountered in vehicle applications.

A bellview washer 210 is used to distress or activate the PZT material

The bellview washer is arranged to have a negative load-deflection curve so that the bellview contacts the PZT material with the same force every time the bellview is pushed beyond a certain critical point or switch threshold. This insures a reliable source of power for the transmitter once the switch threshold is overcome. The higher the height of the bellview, the greater the magnitude of the negative deflection and corresponding distress applied to the PZT material. Using a negative mechanical motion allows the activation process to be independent of the force applied to the

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~~bellview. For a large bellview, thinning part of the bellview will increase the size of the spot needed to be pushed to obtain the maximum negative deflection of the PZT material.~~

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5 To further lower manufacturing costs, a preferred embodiment of the present invention utilizes MEMS technology to integrate the switch components onto a single chip. More specifically, MEMS (Micro ElectroMechanical Systems) is an emerging technology in which mechanical structures and electronic circuits are formed on silicon wafers. One example of a vehicle component that utilizes this approach is an air bag/collision detection sensor. MEMS can be used to form other electronic components such as switches, navigational compasses, relays, and RF transmitters. For example, this manufacturing concept will enable a wireless vehicle side mirror power switch assembly to be integrated on a single silicon chip. The switch would communicate wirelessly with the door mounted outside mirrors, and would have complete freedom of location on the door panel because no wiring harness would be required. The use of MEMS technology would reduce complexity, improve reliability and reduce cost while providing more packaging flexibility. The self-powered wireless switch of the present invention can be used in other areas of the vehicle, including doors, instrument panel and headliner. Multiple switches can be put on a single chip and coupled to one transmitter circuit. An analog indicator, processor or other arrangement can be included to provide individual coding of each switch.  
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25 Referring now to Figure 4, a second embodiment of a self-powered wireless switch 300 is shown in accordance with the present invention, where like elements to the previous embodiment have been denoted with the same reference number. In this embodiment, the energy harvesting arrangement uses at least one tritium lamp 302 and a photovoltaic device 304 to power the wireless transmitter circuit 206. The tritium lamp provides a lightweight, long life energy source. For example, these lamps are now being used to illuminate exit signs on airplanes and watch dials. Tritium has a half-life of 12.4 years and decays to helium by releasing 30 a beta particle with a maximum energy of 18.6 keV. This energy is approximately equal to the energy of the electrons in a television tube. Thus, the products of

tritium decay, i.e., stable helium and electrons, can be contained within a glass sphere 306. The released beta particles have sufficient energy to excite phosphors 308 that can be coated on the inside of the glass sphere containing the gas. Monochromatic light is thus produced to efficiently excite an array of photo detectors 5 in the photovoltaic device. The light intensity is temperature independent since because it is produced through a nuclear process. Over the expected temperature range for car operation, the optical efficiency of the photo detectors is also relatively insensitive to temperature. Thus, the output power from the tritium power source will be relatively independent of temperature.

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~~In operation, a user actuated switch 310 is connected to a control input of wireless transmitter 206. A voltage regulator (not shown) can be included to regulate the supply of power form the photo detectors.~~

The light generated by the tritium lamp(s) can also be used to illuminate (i.e., backlight) the switch. In addition, lighting effects can be obtained 15 by using a plurality of phosphors. In order to attain a twenty-year operational life, a plurality of tritium lamps can be close coupled to the photovoltaic devices, thereby insuring that a sufficient amount light is generated beyond the 12.4 year half-life of the tritium. For example, a set of glass spheres each containing the tritium/phosphor can be sandwiched between a set of photo detector arrays. The output from these 20 arrays provide the power necessary to operate the wireless transmitter.

Further, since these components are relatively small, they can be potted together to make a single element. In a vehicle door application, this element could be mounted behind or under a mirror controller so that controls for a side view mirror would be in direct contact with the wireless chip. In other applications such 25 as jet engines and elevators, the wireless chip/tritium power supply can be separated from the user operated switch 310.

In an alternative embodiment 400 shown in Figure 5, the basic tritium power source is replaced with a black light source. For example, in an automobile, the interior could be illuminated with black light via a bulb 402 located in a headliner

404. A conventional bulb produces black light (UV), and one or more filters 406 can be used to eliminate the visible portion of the optical spectrum. Thus, the black light is invisible to the driver, but can be used to excite phosphors 408 to illuminate switch 312 and simultaneously excite photo detectors 304. Visible light could also 5 be used, but depending on the location, could be a distraction to a vehicle occupant, especially at night. For some applications, generating electrical power via black light or mechanical motion may be more attractive in terms of cost than using the tritium-based power source.

10                 Thus, the self-powered wireless switch of the present invention allows a finger actuated switch to provide sufficient power to operate a wireless transmitter capable of communicating 64 bits of information. The energy harvesting or generating arrangement allows the switch to locally collect or generate energy to power the wireless circuitry as well as to potentially provide light or power for backlighting of the switch.

15                 As noted above, one particular application of the self-powered wireless switch is controlling operation of a door mounted outside mirror. In such an application, motorized mirrors are powered via an H-bridge, which would be controlled via a set of wireless switches within the vehicle. Transmission would occur at the switch, while a receiver located near the H-bridge would receive the 20 signal. A relay can be activated to allow electrical power to energize the mirror motor when a signal is received. In addition to door mounted control switches, the wireless switch of the present invention could be used to control a variety of systems in an automobile.

25                 Thus, while embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.